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THE FACTORS THAT INFLUENCE THE MOTIVATION TO LEARN CHEMISTRY OF UPPER- SECONDARY SCHOOL STUDENTS IN INDONESIA

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Cognitive social theory initiated by Bandura (2001), explains that some human learning processes occur in the social sphere. Humans learn by observing other people's attitudes, emotional reactions, and behavior (Bandura, 1999; Hagger & Hamilton, 2022). This theory developed into a social learning theory that is often used to discuss how a person is motivated to learn something (Koutroubas & Galanakis, 2022; Schunk & DiBenedetto, 2021). In student learning, the social scope is the school, where the learning process occurs. So, it is important to create a conducive school environment to increase student learning motivation. Several ways that can be done include: optimizing learning facilities, improving teachers' learning methods (Ardura et al., 2021), and cultivating a sense of belonging to the school (King-Sears & Strogilos, 2020; Korpershoek et al., 2020). Nevertheless, in science learning practice, it is different. Even though these aspects have been fulfilled, the fact is that students' interest in learning science decreases as they move up to grade level (Molnár & Hermann, 2023; Vedder-Weiss & Fortus, 2012). This fact suggests that other factors influence the structure of students' motivation when learning science. This has made motivation to learn science an interesting topic in education lately.

Experts state that the structural components of science motivation specifically consist of self-efficacy (Schunk & DiBenedetto, 2021; Stewart et al., 2020; Stoeckel & Roehrig, 2021), self-determination (Howard et al., 2021; Ryan & Deci, 2020), intrinsic motivation, career, and achievement (Bryan et al., 2011; Glynn et al., 2011). The components of science motivation are currently widely measured through a psychometric instrument called the Science Motivation Questionnaire II (SMQ II). This questionnaire is periodically formulated by experts and validated through exploratory factor analysis and confirmatory factor analysis in various studies. This questionnaire was not only applied to students majoring in science but also to students majoring in non-science (Glynn et al., 2011). Other researchers state that the SMQ II is valid and reliable (Dixon & Wendt, 2021; Janštová & Šorgo, 2019; You et al., 2018). Interestingly, SMQ II can be used widely and adapted to other fields of science, such as biology, physics, and chemistry (Glynn et al., 2011). The SMQ II was adapted into the Chemistry Motivation Questionnaire II (CMQ II) in learning chemistry.



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Abstract. *The role of motivation in chemistry learning has long been explored and has become an exciting research topic worldwide. The aim of this study was to explore whether gender, class and students' anxiety influenced the motivation to learn chemistry among upper-secondary school students in Indonesia. The Chemistry Motivation Questionnaire II and the Chemistry Anxiety Questionnaire were used to examine the influence of multiple predictors through multiple linear regression analysis tests. Participants in this study were 1,211 upper-secondary school students in Indonesia. This study proves that gender has a significant influence on students' motivation to study chemistry, with female students being more motivated to study chemistry than male students. Interesting research results can be seen in the anxiety variable anxiety, specifically in the chemistry learning anxiety aspect, which has a negative correlation with motivation to study chemistry. The regression model of the three factors revealed in this study accounts for 13.8% of the overall proportion of upper-secondary school students' motivation to study chemistry in Indonesia. The results of this study were corroborated using the interview transcript data with 10 students, who extracted several other predictors to influence motivation to study chemistry, including learning experience, learning environment, and digital literacy.*

Keywords: *chemistry learning anxiety, chemistry motivation, Indonesian upper-secondary school students, cross-sectional research*

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Problem Statement

Chemistry education researchers worldwide compete to use CMQ II as their research instrument. CMQ II has been implemented in various countries, such as Greece (Salta & Koulougliotis, 2015), Spain (Ardura & Pérez-Bitrián, 2018), Türkiye (Cetin-Dindar & Geban, 2015), China (Dong et al., 2020; Zhang & Zhou, 2023a), Brazil (de Souza et al., 2022), and other countries. In Indonesia, research of students' motivation to study chemistry with CMQ II are still rare. On average, motivation to study chemistry in Indonesia is measured using other specific instruments and cannot be generalized broadly, let alone compared to other countries. Not to mention CMQ II, the use of SMQ II in Indonesia is limited only for dental students (Rahmayanti et al., 2020) and in comparative studies of motivation to study science in Korea and Indonesia (Rachmatullah et al., 2018). This fact is a crucial issue to note. If every research on students' chemistry learning motivation is only localized (only in certain areas), then the results will not contribute significantly to the development of chemistry education in Indonesia. Given that Indonesia is a vast and heterogeneous country. Unfortunately, although CMQ II is widely used in other countries, the fact is that using CMQ II as a research instrument in Indonesia seems less attractive to researchers. Hiding chemistry motivation as an affective aspect of students is essential to optimize the effectiveness of chemistry learning in Indonesia.

CMQ II can extract facts about students' learning motivation to study chemistry. Several studies state that the biggest motivation for students to learn chemistry is to get grades, and few students find the relevance of chemistry for their future careers (Austin et al., 2018). Other studies state that motivation to learn chemistry differs significantly by gender (Zhang & Zhou, 2023b) and students' learning experiences (Ardura & Pérez-Bitrián, 2018; Salta & Koulougliotis, 2022).

Many factors cause the learning experience felt by students; it could be a factor of the learning method that the teacher applies (Ardura et al., 2021; Dewi et al., 2019), the learning facilities at school, the social environment of the school, or the learning system implemented —online or offline (Huang, 2020; Jeffery & Bauer, 2020; Kalman et al., 2020). Some factors affect students' motivation to learn chemistry because they are related to learning anxiety. Bad teachers will increase student anxiety when learning (Stomff, 2014). Online learning systems, such as during the COVID-19 pandemic, also caused students to feel anxious, stressed, and depressed (Cervantes-Cardona et al., 2022). In addition, practical learning in the laboratory also increases student anxiety (Kurbanoglu & Akim, 2010). Many studies have mentioned the relevance of anxiety to motivation, but the problem is that none of them relates to chemistry motivation. Even in educational studies in other domains, anxiety has been empirically proven to strongly influence and correlate with student learning motivation (Al Majali, 2020; Süren & Kandemir, 2020). Interestingly, anxiety can increase motivation (Strack et al., 2017) and decrease it (Camacho et al., 2021). This study will reveal this correlation in the context of learning chemistry. The Chemistry Anxiety Questionnaire (CAQ) is used to measure student anxiety.

In summary, there were two issues raised in this study. Firstly, the lack of research on students' chemistry learning motivation conducted widely in Indonesia. Second, no specific research discusses the correlation between chemistry motivation and student learning anxiety. Those two problems were the reasons why this research needs to be conducted.

Research Aim and Research Questions

Seeing the complex structural factors of motivation to learn chemistry, using CMQ II as a research instrument is certainly not enough. Motivation is an affective aspect that needs to be explored in depth, so this study does not only focus on quantitative data from cross-sectional surveys but also qualitative data from interviews with students as a complement. The results of the interviews were useful for enriching the data, so as to reach and explain facts that have not been covered by previous researchers. Implementing CMQ II in developing countries like Indonesia can produce interesting research data, considering that Indonesia has a unique educational culture and is certainly different from other countries. This study aimed to explore the factors influencing upper-secondary school students' motivation to learn chemistry in Indonesia. In line with this aim, the main focus of this research was to answer the following questions:

1. Do differences in gender, class, and anxiety levels influence students' motivation to learn chemistry?
2. Are there other factors that influence students' motivation to learn chemistry?



Research Methodology

General Background

This research used a quantitative approach with a survey method. The survey design chosen was a cross-sectional survey. This research design was implemented to observe without providing intervention to respondents in a relatively short period (Lavrakas, 2008) and appropriate for examining participants' attitudes, beliefs, or opinions (Creswell, 2012), so it is appropriate to use to answer questions in this study. Attitudes, beliefs, or opinions can be interpreted as an individual's way of thinking about a problem, which in the context of this study is the process of learning chemistry. Quantitative data collected through CMQ II were analyzed to detect the five components of motivation to learn chemistry based on gender, class and student anxiety level, so statistical calculations were needed. Almost all studies with CMQ II were conducted using a cross-sectional survey design, so the research data obtained were limited. The survey in this study was combined with interview techniques so the data obtained had a deeper meaning. This design was certainly more effective for explaining, especially the possibility of other factors influencing students' motivation to learn chemistry. Qualitative data analysis from interview transcripts enriched the perspective of researchers in studying and interpreting the survey data in this study.

Technically, this study was conducted in two stages; surveys and interviews. The cross-sectional survey using CMQ II was completed anonymously by the students within three weeks, while the interviews were conducted within two weeks. Overall, this research was conducted over five weeks from January to February 2023. In that month, most upper-secondary schools in Indonesia implemented offline learning after being online for a long time due to the Covid-19 Pandemic. The survey was conducted directly by distributing paper questionnaires to upper-secondary school students.

Participants

The survey participants in this study were 1,211 upper-secondary school students in grades 10, 11 and 12 majoring in Mathematics and Natural Sciences (620 boys and 591 girls) spread across several regions in Indonesia. The sample selection is based on the target population of this study, which is upper-secondary school students in Java and Sumatra, totaling approximately 1 million. The sample was selected based on the accessibility of the researcher to reach the school where the students study. The selection was closely related to school licensing and data collection ethics. Another characteristic considered in selecting participants was the same standard of the learning process, meaning that all schools where the participants studied were accredited A, had access to computers and the internet, and had chemistry teachers who were already undergraduate certified. Based on the survey sample calculation with the variance of the population (P) = 50%, accuracy confidence level = 99%, and margin of error = 5%, the minimum sample value of 660 students was obtained (Taherdoost, 2017). Thus, the total sample in this study is sufficient to represent the target population.

All individuals participating in this study were not subject to intervention or coercion from any party. Students have consciously agreed to participate in surveys and interviews without any compensation. All upper-secondary school students who participated in this study had received chemistry subjects by the applicable curriculum so that participants can objectively answer questionnaires and interviews based on what they feel during learning.

This study followed the ethical procedures of educational research by considering beneficence, justice, and nonmaleficence, especially to the participants. Therefore, the researcher did not conduct data collection in schools that did not give permission. In schools where permission was granted, all students could participate in the study without distinction of gender, ethnicity, race, or religion. Based on the principle of respecting the rights and dignity of the individual, all participants in this study were voluntary; thus, all participants involved were ensured to be undisturbed and not disadvantaged. All data collected were coded following the principles of anonymity and confidentiality.

Instrument and Procedures

Students' chemistry learning motivation was explored through CMQ II (Glynn et al., 2011), while students' anxiety was measured through the CAQ (Chemistry Anxiety Questionnaire) by Megreya et al. (2021), which was adapted into Indonesian through five stages, namely: 1) translation, 2) synthesis, 3) back translation, 4) expert com-



mittee review, and 5) pre-testing (Beaton et al., 2000). The translation of CMQ II and CAQ was carried out repeatedly by two researchers from the chemistry education study program and one linguist. After that, face validation was conducted in a group discussion forum with three chemistry education experts. The Indonesian version of CMQ II consists of 25 question items with five components, namely: intrinsic motivation (IM), career motivation (CM), self-determination (SD), self-efficacy (SE), and grade motivation (GM), which can be seen in Table 1.

Table 1
Chemistry Motivation Questionnaire II (CMQ II)

Items	Question Number	Loading Factor
Intrinsic Motivation		
I enjoy learning chemistry	Q19	.83
I am curious about discoveries in chemistry	Q17	.66
Learning chemistry makes my life more meaningful	Q12	.82
Learning chemistry is interesting	Q3	.79
The chemistry I learn is relevant to my life	Q1	.77
Career Motivation		
I will use chemistry problem-solving skills in my career	Q25	.84
My career will involve chemistry	Q23	.81
Understanding chemistry will benefit me in my career	Q10	.83
Knowing chemistry will give me a career advantage	Q13	.85
Learning chemistry will help me get a good job	Q7	.81
Self Determination		
I study hard to learn chemistry	Q22	.83
I prepare well for chemistry tests and labs	Q16	.77
I spend a lot of time learning chemistry	Q11	.76
I use strategies to learn chemistry well	Q6	.80
I put enough effort into learning chemistry	Q5	.75
Self-Efficacy		
I am sure I can understand chemistry	Q21	.82
I believe I can earn grade 'A' in chemistry	Q18	.69
I believe I can master chemistry knowledge and skills	Q15	.84
I am confident I will do well on chemistry labs and projects	Q14	.76
I am confident I will do well on chemistry tests	Q9	.79
Grade Motivation		
Scoring high on chemistry tests and labs matters to me	Q24	.87
I think about the grade I will get in chemistry	Q20	.78
It is important that I get an 'A' in chemistry	Q8	.84
Getting a good chemistry grade is important to me	Q4	.79
I like to do better than other students in chemistry tests	Q2	.56

CAQ consists of 9 question items with two components: chemistry learning anxiety (CLA) and chemistry evaluation anxiety (CEA), which can be seen in Table 2. Both have answers in the form of a 5-point Likert scale. The pre-testing stage of the instrument was carried out on 338 upper-secondary school students. Construct validation was done by confirmatory factor analysis (CFA) to confirm whether the questionnaire items were valid for measuring latent variables from the Indonesian version of CMQ II and CAQ. The software used was Lisrel 8.8. The criteria



for the validity of the CFA model were observed based on the goodness of fit indices and the loading factor value above .50 (Hair et al., 2010). The reliability of the instrument is calculated using Cronbach's alpha method with reliable instrument criteria based on the value of $\alpha > .7$.

Table 2*Chemistry Anxiety Questionnaire (CAQ)*

Items	Number Question	Loading Factor
Chemistry Learning Anxiety		
Starting a new topic in chemistry	Q9	.72
Listening to another child in your class explains a chemistry problem	Q7	.68
Watching the teacher works out a science experiment on the board	Q3	.54
Listening to the teacher talk for a long time in chemistry	Q6	.75
Finding out that you are going to have a surprise science quiz when you start your chemistry lesson	Q8	.53
Chemistry Evaluation Anxiety		
Taking a chemistry test	Q4	.79
Being given chemistry homework with lots of difficult questions that you have to hand in the next day	Q5	.75
Thinking about a chemistry test the day before you take it	Q2	.55
Having to complete a worksheet in chemistry by yourself	Q1	.52

The results of the CFA test showed that all CMQ II items were valid for measuring the components of chemistry motivation and met the goodness-of-fit criteria with a value of $\chi^2/df = 1.38$, RMSEA = .066, CFI = .99, NFI = .96, GFI = .95 and AGFI = .93. CMQ II items also show a loading factor value of > 0.5 , so it can be concluded that the Indonesian version of CMQ II can be used reliably. Meanwhile, the reliability of the Indonesian version of CMQ II also showed a fairly good Cronbach's alpha value, namely $\alpha = .969$.

The Indonesian version of the CAQ adaptation also shows sufficient validity and reliability to be used. CAQ was constructively reliably used to measure the components of chemistry learning anxiety and chemistry evaluation anxiety with a value of $\chi^2/df = 1.54$, RMSEA = .067, CFI = .97, NFI = .96, GFI = .93 and AGFI = .87. All Indonesian versions of CAQ items also have a loading factor of $> .50$. The Cronbach's alpha reliability of the CAQ adaptation is $\alpha = .803$. Thus, the two instruments used in this study were valid and statistically reliable.

The interviews were conducted using a semi-structured guide arranged systematically by synthesizing similar studies. The direction of the questions from the interviews in this study was to dig deeper into what and how students feel when learning chemistry at school, as well as to confirm the questions in CMQ II. In terms of validity, qualitative instruments are still widely debated (Noble & Smith, 2015). In particular, in this study, the interview guidelines were validated through group discussion forums (FGD) with experts (Creswell & Poth, 2016). The expert validation interview sheet produced 15 flexible questions that were developed according to the respondents' answers. Interview questions in this study were developed based on aspects of chemistry learning motivation so that the results of the interviews remained focused on this study's aims. The interview questions can be seen in Table 3.

Table 3*Chemistry Motivation Interview Questions*

Questions	Aspects
Do you think chemistry is an interesting subject or not?	Intrinsic Motivation
Is there one personal thing or incident that impressed you with chemistry?	
Do you know what kind of job a chemistry person would take when they graduate from school or college?	Career Motivation
Do any of your parents, family or relatives work in chemistry?	



Questions	Aspects
Do you think chemistry is difficult?	Self Determination
What efforts have you made to understand chemistry while at school?	
If suddenly there is an exam, can you answer the chemistry questions (of course, on the topics you have learned)?	Self-Efficacy
Are you confident/unsure about getting a good chemistry exam grade? What is the reason?	
Do you believe chemistry will lead to success in your future studies or career?	
Do you think your chemistry grades are good or not?	Grade Motivation
Is getting a good grade on your report card why you study chemistry?	
Does the teacher's learning that you currently feel makes you excited to learn chemistry? Can you tell us?	
Do you need learning media (power point, website, application, etc.) when learning chemistry? Does it make you more enthusiastic about learning chemistry?	
Does chemistry lab make you excited to learn chemistry? Or does it make you anxious/worried? Are you anxious/worried?	Extrinsic Motivation (Additional Questions)
What else keeps you interested, excited, and enthusiastic about studying chemistry?	

Data Analysis

Regression analysis is used to explore the correlation between the independent and dependent variables in this study. However, the correlation is predictive or approximate. The dependent variable (y) is predicted through the regression equation of two or more predictors according to the model: $y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \dots + \beta_nX_n + e$. This study's independent variables or predictors were gender, class, and student anxiety levels, while the dependent variable was the chemistry motivation component. This study includes dichotomous variables (gender and class), so they need to be changed into dummy variables by giving codes 0 and 1 (Ghozali, 2021; Tabachnick & Fidell, 2013), gender variables are recorded as "female," while class variables are coded repeatedly with the $k-1$ dummy variable conversion formula. Of course, the classical assumption must also be fulfilled as a condition for linear regression with the ordinary least squares (OLS) approach. The tests performed include multicollinearity, heteroscedasticity, normality, and linearity tests. The classical assumption test will be carried out accompanied by multiple linear regression tests, and the results will be displayed in a structured manner in this study.

The feasibility of the regression model is detected through the model feasibility test (F Anova test), regression coefficient test (t -test), and the coefficient of determination (value of R -Square or Adjusted R -Square). Based on these three tests, it can be known whether there is influence or the magnitude of the proportion of predictor influence on the dependent variable. The final stage of the regression analysis is the interpretation of the direction and magnitude of the influence of each predictor on the independent variables. All stages of the regression analysis were carried out with the help of SPSS version 26 software.

The final regression model cannot produce a perfect proportion of influence value (R Square). Qualitative descriptive analysis of the interview transcripts will be added to complement and confirm the predicted results from the regression analysis that has been carried out. That way, the study results will be complete, stronger, and able to explore students' motivation in chemistry more deeply.

Research Results

Multiple linear regression was used to analyze the correlation of the dependent variable, namely the five components of chemistry motivation (intrinsic motivation, career motivation, self-determination, self-efficacy, and grade motivation), with predictors (gender, class, and student anxiety). Classical assumptions must be met in the regression analysis, including the multicollinearity analysis of the independent variables. Table 4 is the results of the multicollinearity test, which shows the tolerance value and variance inflation factor (VIF).



Table 4*Multicollinearity Test Results*

Dependent variables	Independent Variables/Predictors									
	CLA		CEA		X		XI		Female	
	Tol.	VIF	Tol.	VIF	Tol.	VIF	Tol.	VIF	Tol.	VIF
All dependent variables	.781	1.280	.807	1.239	.713	1.402	.728	1.373	.954	1.048

Note. Tol. = tolerance; VIF = variance inflation factors

The table above shows no multicollinearity in the proposed regression model because the tolerance value is $> .20$, and the VIF value is < 10.00 for each predictor. Pearson's r correlation test in Table 5 also confirms this. Pearson's r correlation test was also used to determine which component best predicts students' motivation to learn chemistry. It could be seen that the predictor with the highest correlation with chemistry motivation was gender (female), with a value of $.164 < r < .335$. In this regression model, the best predictor of the chemistry components of motivation was gender.

Table 5*Pearson Correlation Test Results on the Dependent Variables*

Dependent variables	Correlation coefficient (r)				
	CLA	CEA	X	XI	Female
Intrinsic Motivation	-.088**	.109**	.074*	.020	.210**
Career Motivation	-.106**	.030	.131**	.043	.164**
Self Determination	-.140**	.065*	.096**	-.013	.335**
Self-Efficacy	-.065*	.083**	.045	.019	.202**
Grade Motivation	-.066*	-.003	.074**	.019	.249**

Note. * $p < .05$; ** $p < .01$

The multiple linear regression assumption test continued with the Glejser test to detect heteroscedasticity symptoms. The existence of symptoms of heteroscedasticity has implications if the regression model is not accurate and efficient so that the proportion of predictor effect cannot be estimated optimally. The Glejser test in Table 6 proves that the p -value of each predictor for the dependent variable is insignificant ($p > .05$), meaning that there are no symptoms of heteroscedasticity in the proposed regression model. Heteroscedasticity symptoms can also be analyzed through irregular scatterplots that do not form a certain pattern.

Table 6*Results of the Regression Model Heteroscedasticity Test*

Dependent variables	Independent Variable p-value				
	CLA	CEA	X	XI	Female
Intrinsic Motivation	.368	.435	.054	.093	.295
Career Motivation	.390	.253	.082	.674	.053
Self Determination	.152	.070	.080	.052	.113
Self-Efficacy	.625	.069	.053	.130	.055
Grade Motivation	.059	.992	.063	.077	.343



The absence of symptoms of heteroscedasticity and normally distributed data give a signal if the linearity of the data has also been fulfilled. This classical assumption is important to avoid bias toward estimating the specified regression model. Fulfilling the classical assumption implies that the resulting regression model has minimum bias. The results of the calculation of the regression model can be seen in Table 7.

Table 7

Summary of Regression Models and ANOVA All Predictors of the Chemistry Motivation Component

Dependent variables	Model Summary			Anova		
	<i>R</i>	<i>R</i> ²	Adjusted <i>R</i> ²	<i>F</i>	<i>df</i>	<i>p</i>
Intrinsic Motivation	.274	.075	.071	19.633	1210	< .001
Career Motivation	.253	.054	.060	16.539	1210	< .001
Self Determination	.371	.138	.134	38.477	1210	< .001
Self-Efficacy	.237	.056	.052	14.292	1210	< .001
Grade Motivation	.260	.067	.064	17.445	1210	< .001
All Variables	.326	.106	.102	28.584	1210	< .001

It can be seen that the model proposed for all predictors is significant ($p < .05$) with different R^2 values. In this model, it can be seen that the contribution of the proportion of predictor influence is quite small ($.54 < R^2 < .138$). The regression model proposed in this study only contributes to the influence of the 5.4% to 13.8% motivational component. The rest are other predictors that were not explored in this study. Considering various factors (F , p , and adjusted R^2 values), the above model is considered as the best and shows the largest R^2 value compared to other model variations.

In multiple linear regression, the value of b indicates the contribution of each predictor to the model. The value of b can be seen in Table 8, and it can be seen that almost all p values are significant ($p < .05$). Some predictors that are not significant ($p > .05$) will be removed from the equation because they do not affect the dependent variables.

Table 8

Predictor Regression Coefficient on the Chemistry Motivation Component

Dependent variables	Predictors	Coefficient				
		<i>b</i>	<i>b</i> [*]	<i>SD</i>	<i>t</i>	<i>p</i>
Intrinsic Motivation	Constant	15.273	-	0.428	35.683	.001
	CLA	-0.094	-0.120	0.025	-3.818	.001
	CEA	0.160	0.172	0.029	5.569	.001
	X	0.591	0.087	0.223	2.646	.008
	XI	0.312	0.052	0.190	1.640	.101
	Female	1.017	0.184	0.165	6.474	.001
Career Motivation	Constant	15.236	-	0.503	20.279	.001
	CLA	-0.093	-0.101	0.029	-3.193	.001
	CEA	0.096	0.088	0.034	2.830	.005
	X	1.463	0.184	0.263	5.574	.001
	XI	0.906	0.132	0.233	4.054	.001
	Female	0.876	0.129	0.194	4.504	.001



Dependent variables	Predictors	Coefficient				
		<i>b</i>	<i>b*</i>	<i>SD</i>	<i>t</i>	<i>p</i>
Self Determination	Constant	15.629	-	0.439	35.583	.001
	CLA	-0.114	-0.136	0.025	-4.503	.001
	CEA	0.137	0.138	0.030	4.649	.001
	X	0.511	0.071	0.229	2.228	.026
	XI	0.086	0.014	0.195	0.439	.661
	Female	1.904	0.307	0.170	11.217	.001
Self-Efficacy	Constant	16.115	-	0.459	35.207	.001
	CLA	-0.068	-0.081	0.027	-2.561	.011
	CEA	0.125	0.126	0.031	4.041	.001
	X	0.352	0.049	0.239	1.471	.142
	XI	0.223	0.036	0.204	1.094	.274
	Female	1.146	0.185	0.177	6.459	.001
Grade Motivation	Constant	17.093	-	0.483	35.392	.001
	CLA	-0.020	-0.022	0.028	-0.707	.480
	CEA	0.019	0.018	0.032	0.579	.562
	X	0.598	0.078	0.252	2.373	.018
	XI	0.375	0.057	0.215	1.749	.081
	Female	1.556	0.237	0.187	8.336	.001

Based on the results of the regression calculation table above, with consideration of the significance value ($p < .05$), the regression equations are produced as follows:

$$IM = 15.273 - 0.094 (CLA) + 0.160 (CEA) + 0.591 (X) + 1.017 (Female)$$

$$CM = 15.236 - 0.093 (CLA) + 0.096 (CEA) + 1.462 (X) + 0.906 (XI) + 0.876 (Female)$$

$$SD = 15.629 - 0.114 (CLA) + 0.137 (CEA) + 0.511 (X) + 1.904 (Female)$$

$$SE = 16.115 - 0.068 (CLA) + 0.125 (CEA) + 1.146 (Female)$$

$$GM = 17.093 - 0.598 (X) + 1.556 (Female)$$

This equation is used to answer the first question in this study. Based on the analysis of multiple regression tests, it can be concluded that not all predictors (gender, class, and level of anxiety) significantly affect aspects of motivation to learn chemistry. The components of intrinsic motivation (IM), self-determination (SD), and self-efficacy (SE) were influenced by gender and students' anxiety levels. In comparison, career motivation (CM) is influenced by all predictors, while the aspect of class motivation (GM) is only influenced by students' gender. Based on the regression equation, it can be seen that gender is the most influential predictor of the motivational component. At the same time, anxiety affects all components of chemistry motivation except classroom motivation. Meanwhile, class differences did not affect the motivational component other than career motivation.

The maximum value of the proportion of the influence of the proposed regression model is 13.8%. The rest (86.2%) were other predictors not included in the proposed regression model. The value of the resulting proportion is quite small, but this estimation must be accepted as a statistical fact considering that the construction of motivation to learn chemistry is quite complex. Therefore, additional research data is needed. In this case, it is the analysis of the results of interviews with respondents. A summary of the interview transcript coding was compiled and can be seen in Table 9 for easier understanding. Coding is done by grouping certain themes to extract other factors influencing motivation to learn chemistry based on the students' perspectives.



Table 9
Coding of Other Factors That Influence Chemistry Motivation

Factors	Extracted aspects		
	1	2	3
Learning experience	Teachers' learning methods and models	Laboratory experiment	The learning media used by the teacher
Chemistry concept	confusing chemistry concepts	Chemistry lessons that contain calculations	Chemistry concepts get more difficult as the class progresses
Learning environment	Friendship and class environment	School facility	Family career in chemistry
digital literacy	Get to know chemistry via the internet	Learn chemistry via the internet	Doing chemistry assignments via the internet
Students' anxiety	Teachers who are not good at teaching	Sudden chemistry test	Laboratory experiment

There were five factors extracted from the interview transcript analysis, including 1) students' learning experiences, 2) chemistry concepts, 3) students' environment, 4) students' digital literacy level, and 5) students' anxiety.

Concerning the students' learning experiences, the aspect that appears most often is teacher learning. All interview respondents agreed that the teacher is the most influential factor in their motivation to learn chemistry. A good chemistry teacher will increase students' motivation to learn chemistry. In addition, the practical aspect cannot be forgotten. Students' motivation to learn chemistry is closely related to learning in the laboratory (practicum). Besides not being boring, learning with experiments in the laboratory is more meaningful and more manageable for students to understand.

Factors that influence motivation to learn chemistry do not arise only from the outside. The concept of chemistry is an internal factor influencing students' motivation to learn chemistry. Chemistry content is unique and specific, which includes concepts and calculations. Not all students are interested in chemistry because of the characteristics of chemistry concepts.

In line with the cognitive social theory, the environment is one of the factors that influence motivation to learn chemistry based on the results of the interviews. The environment in this context is related to the friendship conditions of students, school facilities, and family careers in chemistry. Students with relatives who work in the chemistry field are indicated to be more motivated to learn chemistry; this is related to career motivation.

Students' motivation to learn chemistry is also related to digital literacy. The accessibility of students to the internet allows them to get to know and learn more about chemistry. Students' proximity to the internet indirectly motivates them to learn chemistry more deeply.

The last factor synthesized from the interview results is the anxiety factor. The chemistry anxiety questionnaire (CAQ) and multiple linear regression tests in this study have predicted the anxiety factor. The students' anxiety was evident from the analysis of the interview transcripts. Another aspect of anxiety that needs to be considered as a motivating factor is the nature of the teacher when teaching. Student motivation tends to decrease when they are taught by teachers who are not communicative. In a sense, teachers are too rigid when teaching, often give sudden tests and get angry if students do not understand the chemistry concepts. In addition, in terms of practicum anxiety, male students tend to be more motivated to learn chemistry in laboratory practice than female students.

Discussion

This study aimed to explore the factors influencing upper-secondary school students' chemistry learning motivation through multiple regression analysis and analysis of interview transcripts. In the multiple regression analysis, the predictors determined were gender (female), class (X and XI), and chemistry anxiety (chemistry learning anxiety and chemistry evaluation anxiety). The introduction explains that these three predictors are likely to influence students' motivation to learn chemistry. This study provides strong evidence that not all predictors have a significant effect, even though they are statistically correlated.



Concerning the correlation between the independent and dependent variables, measurements were carried out with the Pearson correlation coefficient (r), which can be seen in Table 4. The data shows two exciting things: the level of correlation between variables included in the low category and the predictor of chemistry learning anxiety (CLA) that is negatively correlated. This low level of correlation is also confirmed by the results of R^2 in Table 7. Gender in this study is the predictor with the highest correlation; this confirms other studies, such as those conducted by De Souza et al. (2022) and Zhang and Zhou (2023).

Previous studies have shown that gender has a relatively small or medium effect (Glynn et al., 2011; Zhang & Zhou, 2023); this study also says so. Gender only had a slightly statistically significant effect ($.164 < r < .335$). The most considerable correlation of gender predictors is on the self-determination variable, which also confirms previous science research (Glynn et al., 2009, 2011). Correlation with a positive value implies that female students are more motivated to learn chemistry than male students. Gender predictors are statistically significantly different; the results of this study are the same as in previous studies (Salta & Koulougliotis, 2022; Zhang & Zhou, 2023).

The analysis results were also supported by the fact that upper-secondary school students in Indonesia who went on to major in chemistry were predominantly female. Even in some universities in Indonesia, male chemistry majors make up at most 20% of students. In addition, academic research in the UK also states that women prefer chemistry at the upper-secondary school level (Crossdale et al., 2022). Gender disparity research in chemistry learning was also conducted in central Florida by Semerzier (2021). The research implies that female students (black and Latina) dominate the university community. This gender factor ultimately impacts all career stages in the world of work in chemistry.

Another predictor that was measured in this study was class differences (X, XI, and XII). The low coefficient value ($-.013 < r < .131$) implies that class differences did not significantly influence students' motivation to learn chemistry. In previous studies, it has been revealed that academic majors have low and moderate correlations (Salta & Koulougliotis, 2022). In line with this study, at the upper-secondary school level, class differences also did not significantly affect motivation to learn chemistry. An analysis of the interview results confirmed these results. The interview transcripts show no indication that class differences influence motivation. However, two respondents said that chemistry concepts became more difficult as the class level increased—this interview results are in line with the study by Molnár and Hermann (2023) and Vedder-Weiss and Fortus (2012). So, there is a tendency that the higher the class level of students, the lower their motivation to learn chemistry.

The decline in motivation to learn chemistry made upper-secondary school students not optimally do the national or end-of-school exams when class XII. So, it is unsurprising that many upper-secondary school chemistry exam scores in Indonesia are in the low category (Ferdhiana et al., 2017). Not to mention, Indonesia has many areas classified as rural and needs help accessing educational facilities. Thus, the chemistry exam results of students in rural areas are consistently lower than those of students in urban areas (Adlim et al., 2014). This socio-demographic factor causes the motivation to learn chemistry among upper-secondary school students in Indonesia to be quite heterogeneous.

Chemistry anxiety, which was appointed as a predictor in this study, also did not have a statistically significant effect on motivation to learn chemistry ($-.140 < r < .109$). However, an interesting finding that needs to be considered is the low correlation of the predictor of anxiety level, which is hostile ($-.140 < r < -.065$) on students' motivation to learn chemistry. The implication is that there is an inverse correlation between the two variables. The higher the students' anxiety, the lower their motivation to learn chemistry. This interpretation is also confirmed by the negative regression coefficient b in Table 6. Analysis of the interview results also reinforces this. An anxiety factor is extracted and influences students' motivation to learn chemistry. The causes of chemistry learning anxiety revealed by respondents were anxiety when taught by uncommunicative teachers and when experimenting in the laboratory. This anxiety is, in fact, also closely related to the learning experience in class, as revealed in another CMQ II study by Vedder-Weiss and Fortus (2013) and Zhou et al. (2019)

The teacher can reduce anxiety in learning chemistry. One way is collaborative active learning (Guo et al., 2022). An active learning environment can increase students' interest and competence in chemistry (Hendrikson, 2021). Passive and dogmatic students tend to be anxious and worried when receiving chemistry learning in class.

Based on the five regression equations extracted from statistical calculations, insignificant effects are often found in predictors of class differences. Meanwhile, the predictor that always appears in the regression equation is gender difference (female). This finding contrasts the results of a study by Salta and Koulougliotis (2022) which said that gender was not included in the regression equation that was formed. It can be said that gender difference in this study is the predictor that has the highest predictive power of students' learning motivation to learn chemistry



(with a value of b , $0.876 < b < 1.904$). In terms of grade motivation and self-determination, the predictive value of gender is the largest compared to the others. These statistical results prove that gender predicts motivation to learn chemistry that must be maintained in the context of other motivation to learn chemistry studies. If you look at the interview transcript, then there is a gender difference which is quite striking. For example, answering the question, "What made you interested in chemistry?"

Male respondents tended to answer in the context of experiments in the laboratory, as stated in the opinion of *participant ID5* below.

"I prefer studying chemistry while doing experiments in the laboratory. Practicing in the laboratory is more interesting than learning theory in class. With practicum, I understand the material presented more quickly. Apart from that, the practicum is fun and does not make you bored,"

The ID5 participant's opinion is correct. Learning in the laboratory does increase motivation to learn chemistry (Yunita, 2017). The problem is that many schools in Indonesia need lab facilities. However, virtual labs can overcome this (Sasmito & Sekarsari, 2022). Meanwhile, female respondents tended to answer in the context of classroom learning and interesting chemistry content, as stated in the opinion of *Participant ID1*.

"Learning chemistry is fun because the teacher is good at teaching it. I like to learn new things like elements and chemistry reactions. I think chemistry is easy enough for me to understand."

Based on these two opinions, it can be concluded that gender remains one of the predictors that significantly affects motivation to learn chemistry, even though the correlation is low. Teachers with suitable learning methods will undoubtedly increase students' learning motivation (Salta & Koulougliotis, 2015). Thus, teachers need to integrate modern learning media such as augmented reality, virtual reality, gamification, and 3D visualization to increase the attractiveness of chemistry lessons in the eyes of upper-secondary school students.

Regarding the negative Pearson correlation test results, predictors of anxiety levels should not be underestimated either. This study provides sufficient evidence to state that students' anxiety significantly affects motivation. The higher the students' anxiety, the lower their motivation to learn chemistry. This was confirmed by the opinion of *participants ID3*.

"One thing I was worried about when studying chemistry was teachers who were not communicative. Sometimes, teachers like that give explanations that are difficult to understand and often give sudden tests without notification."

The influence of the teacher on the motivation to learn chemistry certainly also applies vice versa. In Indonesia, there are still many teachers who are temperamental when teaching. So that there was no activeness and freedom of learning from students. Students tend to be afraid and passive when learning in class. A temperamental teacher will only increase student anxiety. Such anxiety certainly has a negative impact on learning chemistry (Chhetri et al., 2022).

Returning to the fact that motivation is an affective aspect of humans, it is unsurprising that many factors influence it. The regression model proposed in this study only contributes 13.8% of the total proportion of chemistry motivation factors; other factors have also been extracted from the interview transcripts. Of course, other factors need to be studied and explored more deeply. Thus, studies on students' motivation to learn chemistry are getting more complete and positively contributing to the future of chemistry learning.

Conclusions and Implications

This study tries to reveal whether differences in gender, class, and anxiety levels influence students' motivation to learn chemistry. Aspects of chemistry motivation as the dependent variable in this study include intrinsic motivation (IM), career motivation (CM), self-determination (SD), self-efficacy (SE), and grade motivation (GM). Through multiple regression analysis and interview transcript analysis, it can be concluded that:

Gender differences affect motivation to learn chemistry, although the correlation is not large. Female students have a higher incentive to learn chemistry than male students. The regression analysis found that gender was still consistent in providing the proportion of influence on each aspect of chemistry motivation. Analysis of the results



of the interviews also said so. The perspectives of male and female students are opposite in answering the same questions. Thus, future studies on students' motivation to learn chemistry are expected to consider gender aspects as one of the predictors.

The class difference has a smaller proportion of influence than other predictors. Thus, this study has provided sufficient evidence that class differences are not urgent to be used as a motivational factor for learning chemistry. In addition, low correlation does not have important implications for a study, and chemistry learning.

The predictor to consider is students' anxiety. This study proves that anxiety has a significant and statistically negatively correlated effect. It would be interesting to explore the level of students' anxiety as a predictor of motivation to learn chemistry in other contexts.

As for the implications for future studies, CMQ II as an investigative instrument of motivation to learn chemistry will be more complete if combined with qualitative research methods. This study will be more accurate if it uses sequential explanatory mixed methods so that the effect of the predictors investigated can be explored more deeply and it can also extract other predictors. This study also extracted other factors influencing motivation to learn chemistry from the interview transcript analysis, including learning experience, chemistry content, environmental, and digital literacy factors. Thus, other researchers in the future may use these factors as predictors of motivation to learn chemistry in different study contexts.

For the implications for learning chemistry in upper-secondary school, the teacher figure is still the most decisive aspect in shaping students' motivation to learn chemistry. Thus, teachers must consider methods, models, and learning media. It is also essential to pay attention to the intensity of learning in the laboratory when delivering chemistry material, considering that chemistry contains materials that need to be studied based on experiments in the laboratory. Other things teachers need to consider when teaching chemistry are optimizing digital literacy in chemistry, creating a comfortable school environment for learning chemistry, and providing psychological support for students.

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Declaration of Interest

The authors declare no competing interest.

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